Estimating Motor Fuel Demand in South Carolina

The Dunbar-Martin Demand Model

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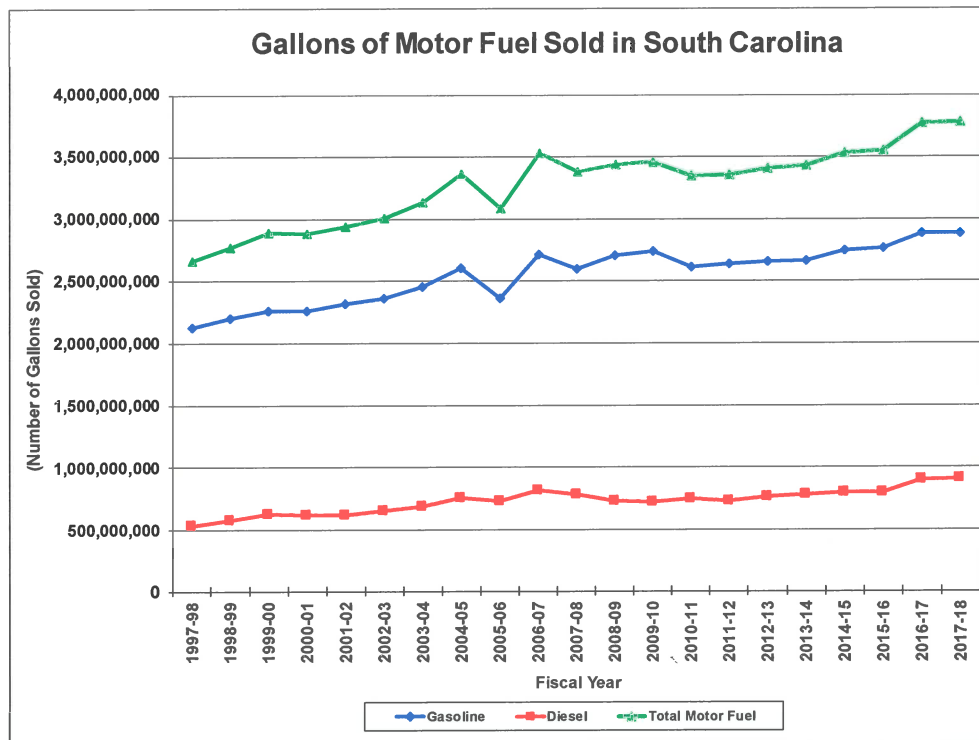Chief Economist

August 1, 2018

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I. Introduction

Each year, over four million registered vehicles travel a combined fifty-five billion miles along the state's more than 68,300 miles of public primary and secondary highways. As a result, motorists consumed more than three and one-half billion gallons of motor fuel as shown in the graph below. Gasoline is consumed at a rate of 3.5 to 1.0 more than diesel fuel. Total motor fuel collections yielded nearly $600,000,000 in FY2017-18. The majority of these funds are allocated to the State Non-Federal Aid Highway Trust Fund for use in repairing the state's roads and bridges.

Gallons of Motor Fuel Sold in South Carolina

This report is organized in the following manner. After a brief introduction, Section II of the report provides a concise review of the motor fuel model by comparing the actual results from the previous fiscal year with the forecast values. Section III discusses a legislative change that will increase the state excise tax rate on gasoline and special fuels in the future. Section IV of the report provides a short background of the state excise tax on gasoline and diesel fuel in the State of South Carolina. Section V derives and specifies the equations used to determine the forecast levels and growth rates of gasoline and special fuel (diesel) revenue collections. Section VI discusses the research findings of the motor fuel demand model results, while Section VII provides a conclusion.

II. Review of the Dunbar-Martin Motor Fuel Demand Model Results

In FY2017-18, the results of the Dunbar-Martin motor fuel demand econometric model were very successful. The accompanying table and chart below compares the actual revenue collections for gasoline, special fuels (diesel), and total motor fuels versus the forecast level of each type of motor fuel predicted by the econometric model in FY2017-18.

**South Carolina Motor Fuel Demand Model Results**
Actual versus Forecast
FY2017-18

			Change From Forecast	
			Dollar	Percent
Type of Fuel	Actual	Forecast	Difference	Difference
	($ Mil.)	($ Mil.)	($ Mil.)	(%)
Gasoline	$369.743	$378.495	($8.752)	(2.31)
Special Fuels	$113.530	$116.279	($2.749)	(2.36)
Total Motor Fuel	$483.273	$494.774	($11.501)	(2.32)

Source: The Dunbar-Martin Motor Fuel Demand Model

Each of the separate econometric models performed well last fiscal year. The gasoline fuel tax model forecast excise tax revenue of $378.5 million in FY2017-18. Actual tax revenues finished $8.8 million, or 2.31% below forecast, at the end of the fiscal year. The special fuels tax model finished the fiscal year $2.8 million

short of the excise tax estimate. Overall, actual excise tax revenue collections of $483.3 million were $11.5 shy of the $494.8 million predicted by the combined motor fuel excise tax revenue models in FY2017-18. This represents a combined margin of error of 2.32 percent.

The graph below depicts the relationship between actual motor fuel excise tax revenue collections and forecast motor fuel excise tax collections. The actual and forecast revenue amounts for each type of motor fuel closely match one another. This illustration reinforces the explanatory ability of the motor fuel demand model as a predictive model of future motor fuel demand in South Carolina.
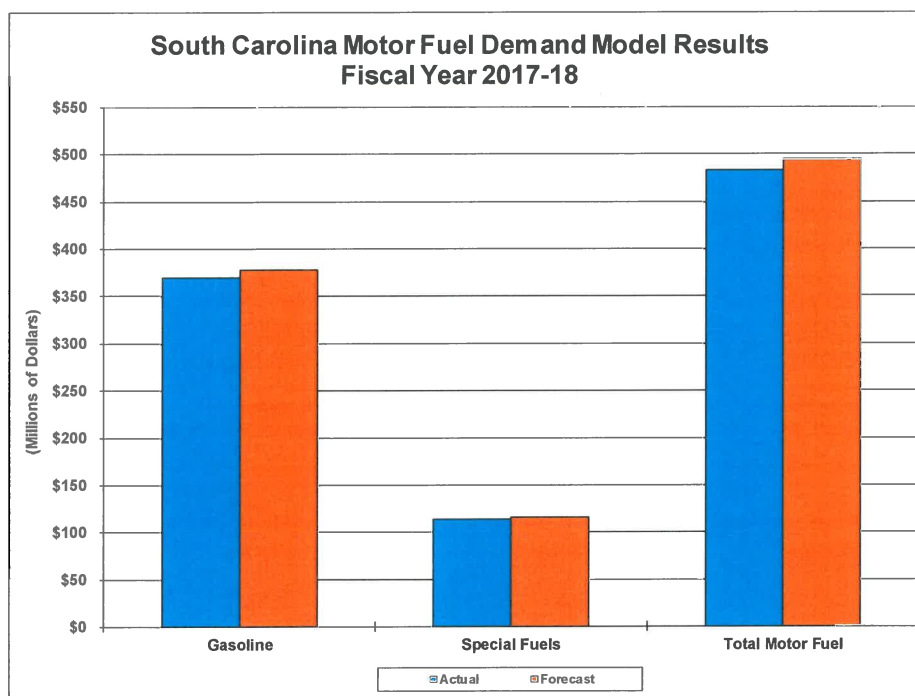
A significant reason for the motor fuel shortfall from the results of the econometric model was a sharp increase in the price of oil and a concomitant rise in gasoline prices during FY2017-18. The graph below depicts the spot crude oil prices of West Texas Intermediate (WTI) crude oil and Brent crude oil over the latest five-year period. WTI is drilled in Oklahoma and Texas and is the oil price benchmark for the United States and most of the Western hemisphere. During the July/August period at the beginning of FY2017-18, WTI was in the $45 per barrel to $50 per barrel range with little indication of an upswing in price. Even

the U.S. Department of Energy did not incorporate a price increase in oil prices into their economic forecasts. During FY2017-18, the Organization of Petroleum Exporting Countries (OPEC) signed a Declaration of Cooperation with all member nations and some non-member nations and agreed to cut oil production throughout the year. As a result, crude oil prices sharply rose from $45 per barrel of oil to $70 per barrel of oil in FY2017-18 as shown in the graph below.
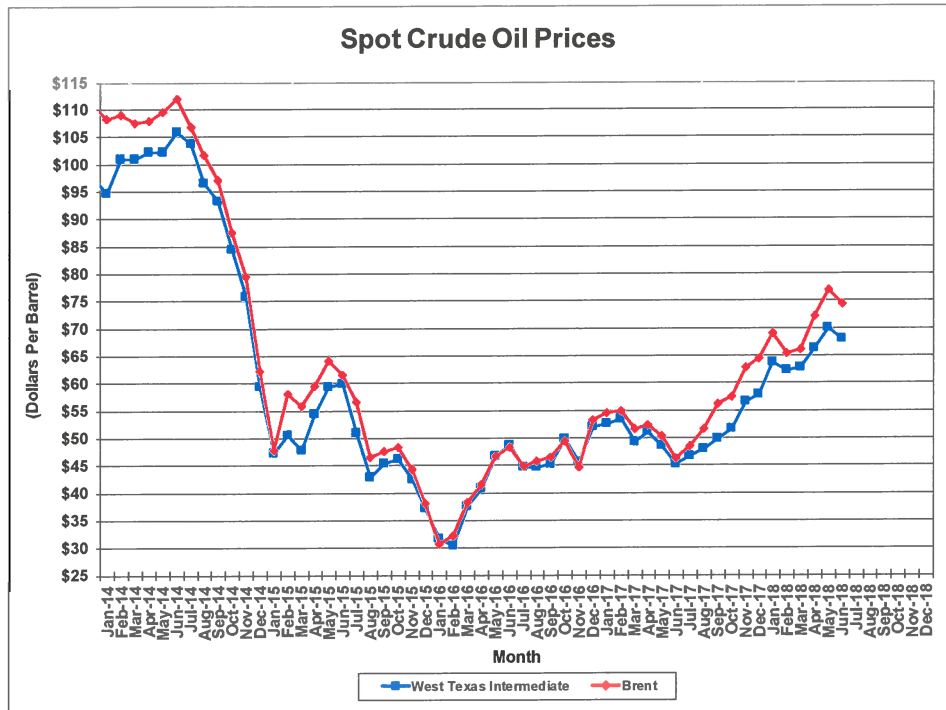
As a result of increased oil prices, the price of motor fuel, both gasoline and diesel fuel, rose throughout the fiscal year. As the graph below indicates, the price of gasoline in South Carolina rose from sub-$2.00 per gallon at the start of FY2017-18 to over $2.50 per gallon by the end of the fiscal year. The econometric model did not incorporate a fifty-cent increase in the price of gasoline in the base economic assumptions. The resulting gasoline forecast, therefore, was somewhat overstated from the relatively low gasoline prices in the model.

Gasoline Prices in South Carolina
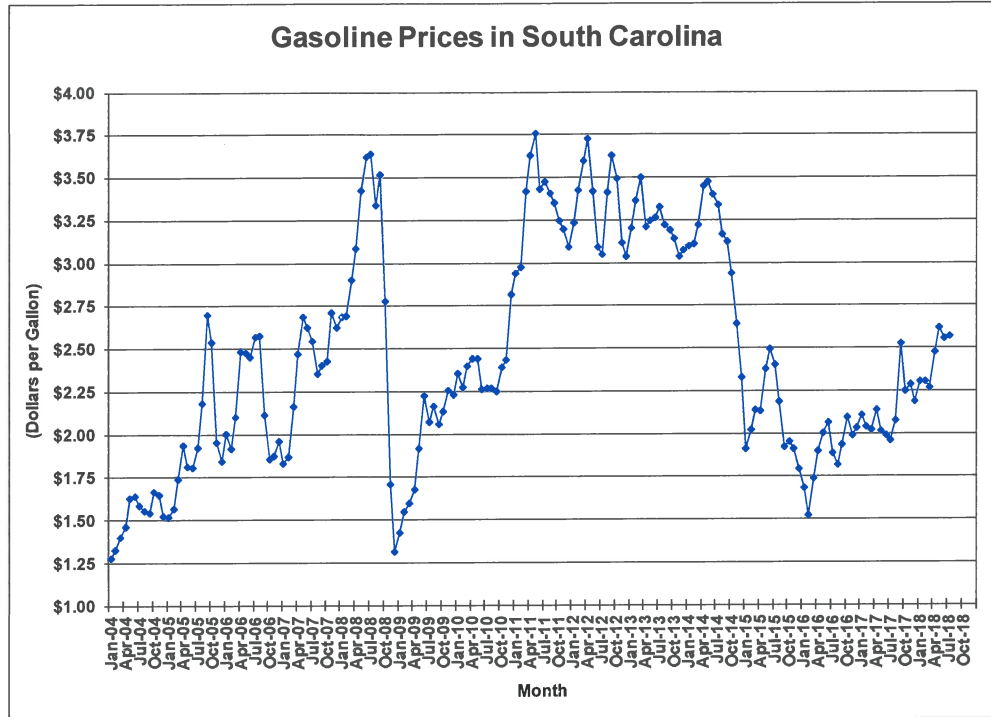
III. South Carolina Infrastructure and Economic Development Reform Act

In 2017, the General Assembly passed an infrastructure bill to provide a recurring source of revenue for road and bridge maintenance and construction. Act 40 of 2017 increased the motor fuel excise tax for the first time in thirty years. The motor fuel excise tax will be increased by two cents each year for six consecutive years. The first increase of two cents went into effect July 1, 2017 and raised the excise tax to 18.75 cents for FY2017-18. The excise tax was increased by another two cents to 20.75 cents per gallon on July 1, 2018. The excise tax will be raised by another two cents to 22.75 cents per gallon of motor fuel in FY2019-20. The additional two cents increase each fiscal year will be set aside in an Infrastructure Maintenance Fund at the Department of Transportation where the proceeds will be used for road and bridge repairs throughout the state. This bill also increased a variety of motor vehicle registration fees and increased the maximum sales tax owed on motor vehicles sold by $200 from $300 to $500 per item.

IV. Background of State Excise Tax Rates on Motor Fuel

In South Carolina, the excise tax on gasoline was adopted in 1922 and fixed at two cents per gallon of gasoline. This was ten years before the enactment of the gasoline excise tax by the federal government. Since then, the excise tax has been raised thirteen times and was last increased in 2018 where it currently resides at twenty cents per gallon of motor fuel. The excise tax rate is the same for gasoline, diesel fuel, and alternative fuels, either for on-highway or off-highway use. The table below shows a schedule of state excise tax changes over time.

South Carolina Motor Fuels Tax Rates
**By Date of Tax Rate Change**
(Cents Per Gallon)

Year	Tax Rate	Legislative Enactment
1922	2 cents	Act 494 of 1922
1923	3 cents	Act 146 to 1923
1925	5 cents	Act 34 of 1925
1929	6 cents	Act 102 of 1929
1958	7 cents	Act 855 of 1958
1972	8 cents	Act 1575 of 1972
1977	9 cents	Act 141 of 1977
1979	10 cents	Act 197 of 1979
1980	11 cents	Act 506 of 1980
1981	13 cents	Act 177 of 1981
1987	15 cents	Act 197 of 1987
1989 1/	16 cents	1/
2017 2/	18 cents	Act 40 of 2017
2018 2/	20 cents	Act 40 of 2017

Note: 1/ Increase tax rate on gasoline and special fuels to 15 cents per gallon on July 1,1987. Tax rate increased to 16 cents per gallon on January 1, 1989.

2/ Increase tax rate on gasoline and special fuels to 18 cents per gallon on July 1, 2017. Tax rate to increase by 2 cents each year until tax rate equals 28 cents per gallon.

Sources: South Carolina Department of Revenue; U.S. Department of Transportation, Federal Highway Administration, Office of Highway Policy Information, Washington, D.C.

The graph below shows the increase in the excise tax on motor fuel in South Carolina and the United States since 1922. In FY2019-20, the motor fuel excise tax in South Carolina will be six cents more than the excise tax nationwide.

Tax Rate Per Gallon of Gasoline in SC and US
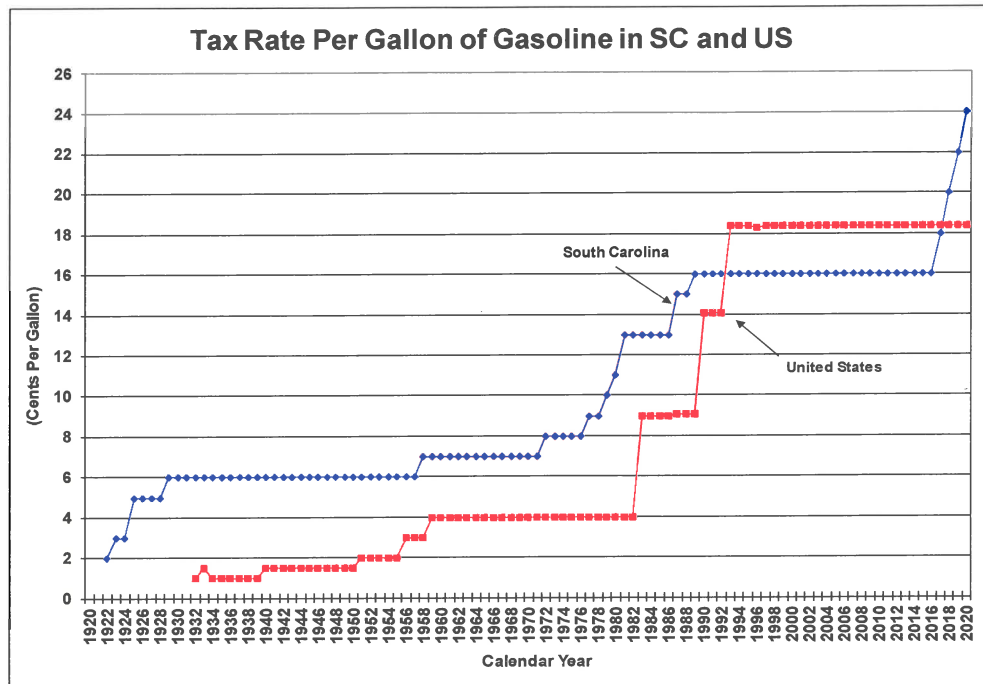
In 1995, two additional fees were added to the motor fuel excise tax rate. A fee of one-fourth cent a gallon was added for the purpose of providing funds for inspecting, testing, and analyzing petroleum products. The fee is divided as ten percent to the Department of Agriculture for use in inspecting and calibrating motor fuel pumps at service stations, and ninety percent is transferred to the State Non-federal Aid Highway Fund within the Department of Transportation. Also, a fee of one-half cent a gallon was imposed as an environmental impact fee to fund the Department of Health and Environmental Control's program of inspecting and monitoring motor fuel storage tanks for leaks or contamination. Collectively, these fees added an additional seventy-five one hundredths of one-cent per gallon to the excise tax rate of sixteen cents per gallon for a combined state motor fuel excise tax rate of $0.1675 per gallon of motor fuel.

The highway infrastructure bill redirected the Department of Agriculture's share of the inspection fee to the State Non-Federal Aid Highway Fund so that the Fund receives one hundred percent of the inspection fee. The Department of Health and Environmental Control will continue to receive the revenue generated by the one-half of one cent environmental inspection fee.

Motor Fuel User Fees in South Carolina
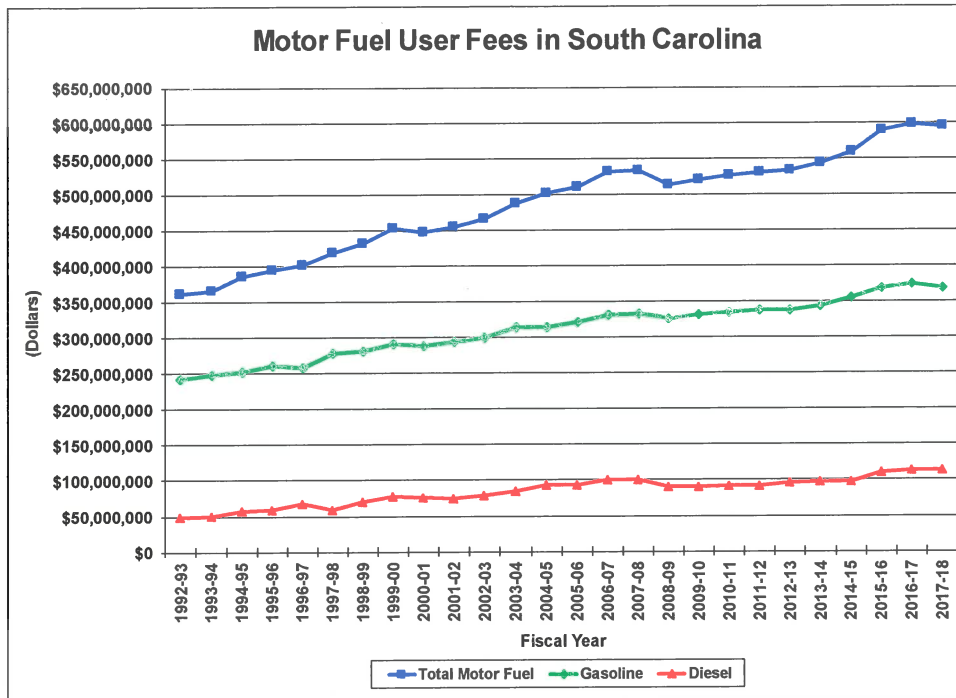
The table above shows the amount of revenue collected from the state excise tax on gasoline and diesel fuel. During the majority of this time period, the state motor fuel excise tax rate per gallon has been fixed at $0.16 per gallon of fuel. In FY2017-18, gasoline tax revenue reached nearly $370,000,000 and the diesel fuel revenue yielded an additional $113,500,000 from the 13-cent component of the motor fuel tax. The additional 3.75-cents per gallon are earmarked for designated purposes other than the construction of and repair of roads and bridges. The effects of the national recessions in 2000-01 and 2007 through 2009 can clearly be seen in the graph below.

Growth in Motor Fuel User Fees in South Carolina
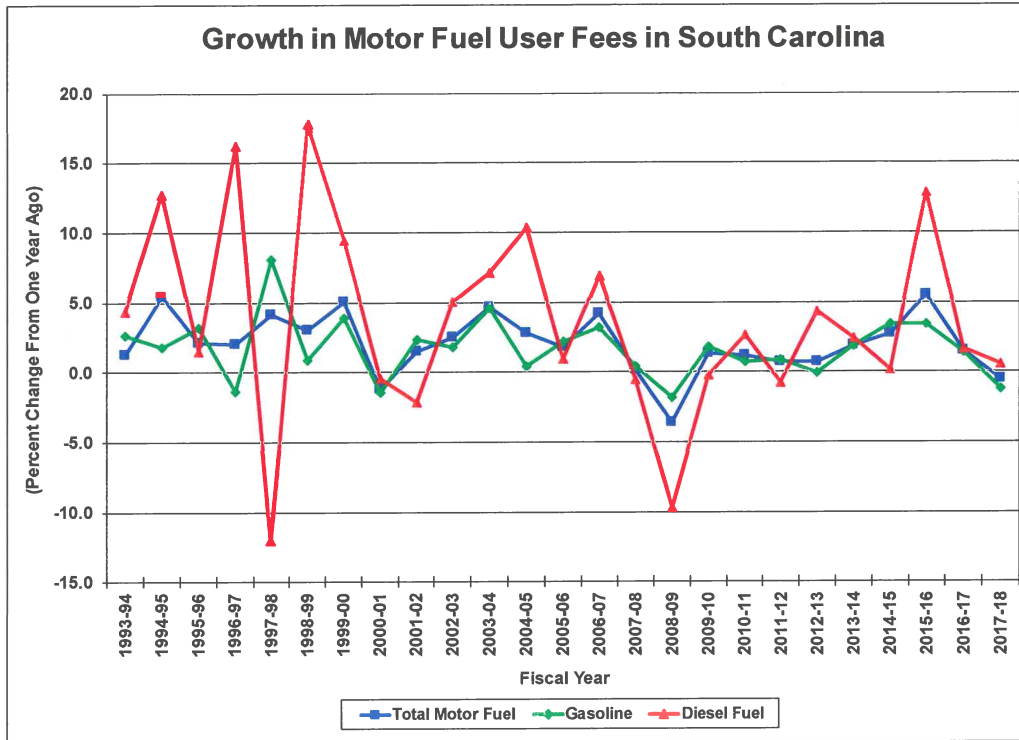
The graph above shows the growth in motor fuel user fees over time. The rate of growth of gasoline appears to be more stable than the rate of growth of diesel fuel. While each is subject to changing economic conditions, diesel fuel is subject to wider swings in the rate of growth than is gasoline. This may suggest that diesel fuel is subject to different economic factors than gasoline. Since FY1993-94, the average rate of growth of all motor fuel was 2.02 percent. Gasoline averaged an annual compound growth rate of 1.71 percent and diesel fuel averaged 3.63 percent rate of growth.

A. The Infrastructure Maintenance Trust Fund

The two-cent increase in the motor fuel excise tax as a result of passage of the highway infrastructure bill must be credited to the Infrastructure Maintenance Trust Fund within the Department of Transportation. In FY2017-18, the two-cent increase in motor fuels amounted to $67.8 million over the first eleven months of collections. Since the excise tax increase started on July 1, 2017, the revenue collected during July was recorded in August. Therefore, only eleven months of

excise tax revenue was recorded in FY2017-18. In FY2018-19, and each fiscal thereafter, there will be twelve full months of revenue collections.

Infrastructure Maintenance Fund Revenue in South Carolina
Fiscal Years 2018-19 to 2019-20

Fiscal Year	Gasoline (Millions)	Special Fuels (Millions)	Total (Millions)
FY2017-18 a/	$51.881	$15.918	$67.799
FY2018-19 b/	$109.967	$34.387	$144.354
FY2019-20 b/	$163.017	$51.780	$214.797

Notes: a/: eleven months of actual revenue collections.

b/: twelve months of projected revenue collections.

Source: SC Board of Economic Advisors

In the table above, the Infrastructure Maintenance Fund is forecast to receive an estimated $109.967 million from a total of a four-cent increase in the motor fuel excise tax rate, and special fuels is forecast to receive an estimated $34.387 million in FY2018-19. These amounts include a full twelve months of excise tax revenue collections. Also, the Infrastructure Maintenance Fund is forecast to receive an estimated $163.017 million from a total of a six-cent increase in the motor fuel excise tax rate, and special fuels is forecast to receive an estimated $51.780 million in FY2018-19. Collectively, the Infrastructure Maintenance Fund is forecast to receive an estimated $144.254 million in FY2018-19 and an estimated $214.797 million in FY2019-20.
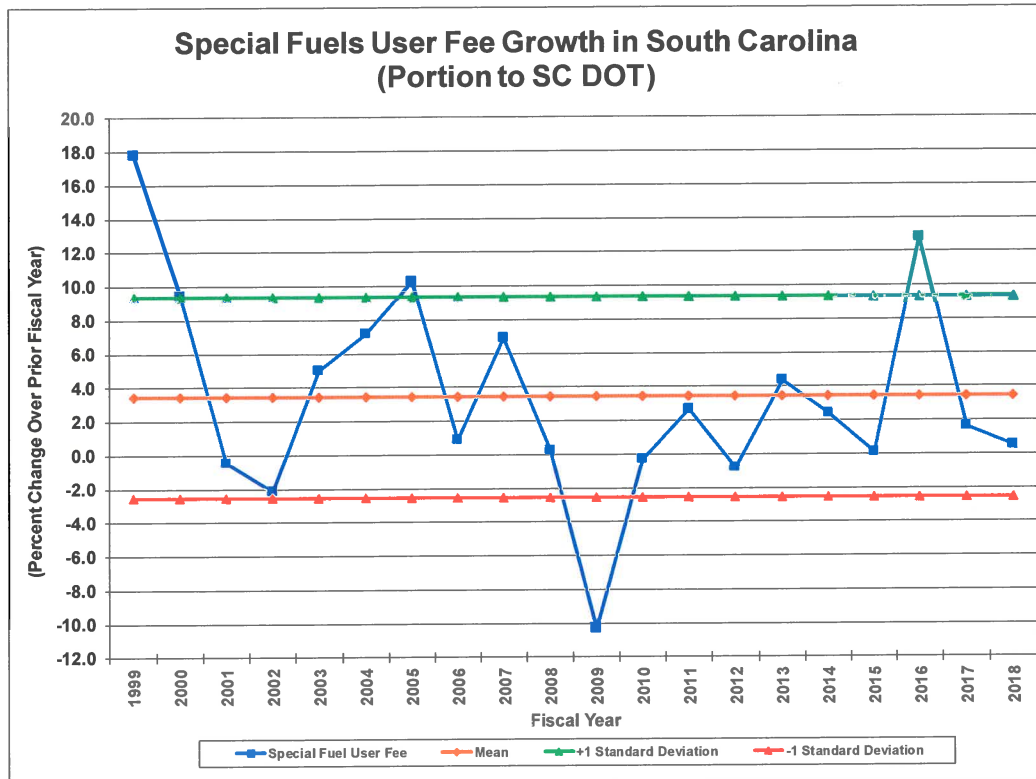
B. Standard Deviation of Motor Fuel User Fees

As a further check to confirm if the model results are reasonable, the growth rates of gasoline, special fuels (diesel), and total motor fuel were plotted over a twenty-year period in the graphs below. The mean growth rate for each variable over the twenty-year period is displayed. Also depicted is a line representing one standard deviation above and one standard deviation below the mean growth rate of gasoline, special fuels, and total motor fuels. One standard deviation from the mean of a variable is generally considered an acceptable degree of confidence that a forecast variable would lie within a range of observed values. Each of the results of the motor fuel model is within one standard deviation of the mean of each variable in FY2018-19 and FY2019-20.

In FY2017-18, actual growth in gasoline excise tax revenue collections declined below one standard deviation of the twenty-year average of gasoline excise tax revenue growth rates. The only other years in the latest twenty-year period was during periods of national recession. South Carolina did not experience a recession in FY2017-18, but the negative growth in gasoline excise tax revenues was largely due to a rapid increase in gasoline prices through the fiscal year. The graph below depicts these relationships.

Gasoline Fuel User Fee Growth in South Carolina
(Portion to SC DOT)
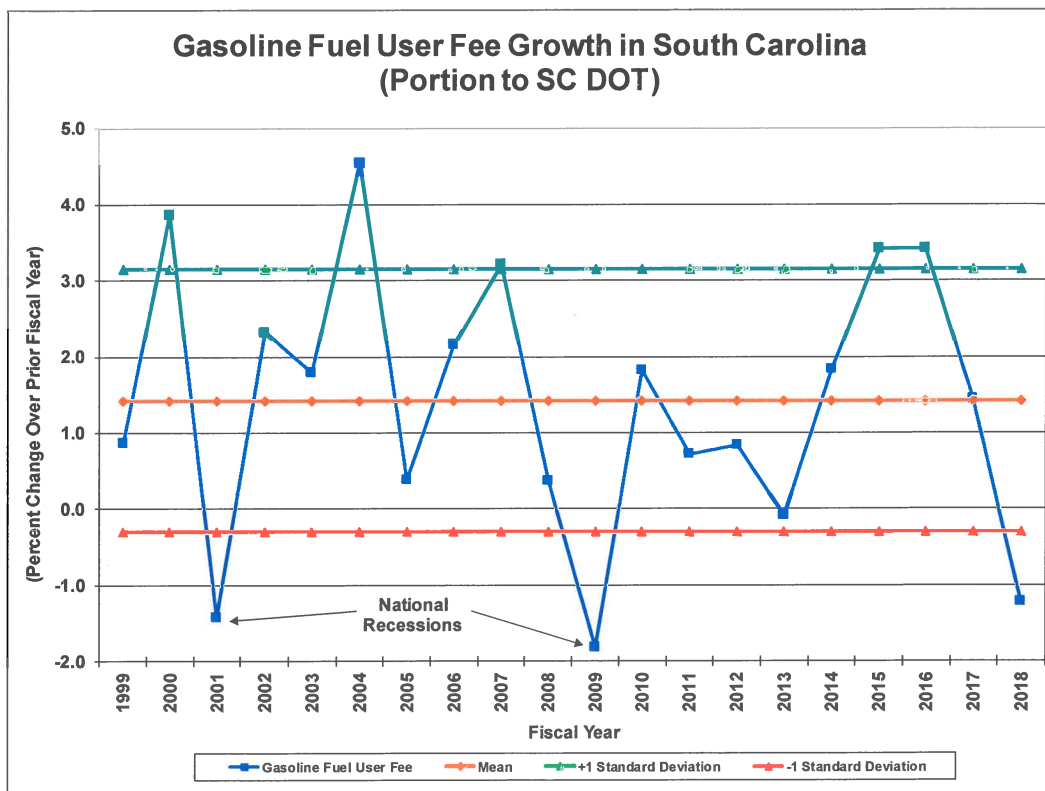
Although the diesel fuel excise tax revenue growth was barely positive in FY2017-18, the growth was within one standard deviation of the mean of diesel fuel tax growth over the past twenty fiscal years. This is within a range of acceptable values for FY2017-18.

Special Fuels User Fee Growth in South Carolina
(Portion to SC DOT)

Total motor fuel excise tax revenue growth rate exhibits the same characteristics as the standard deviation of the gasoline excise tax revenue chart above. This is not surprising since gasoline excise tax revenues are eighty percent of total motor fuel excise tax collections. Overall, the final motor fuel excise tax revenue collections finished more than one standard deviation from the mean of motor fuel user fees over the latest twenty-year period. This indicates that an assumption in the motor fuel model changed abruptly during the fiscal year, or that something outside of the structure of the model was not accounted for in the model specification. We have already discussed the impact of the change in gasoline prices during the fiscal year. If those changes are accounted for in the model, the forecast accuracy of the motor fuel model is greatly improved.

Total Motor Fuels User Fee Growth in South Carolina
(Portion to SC DOT)
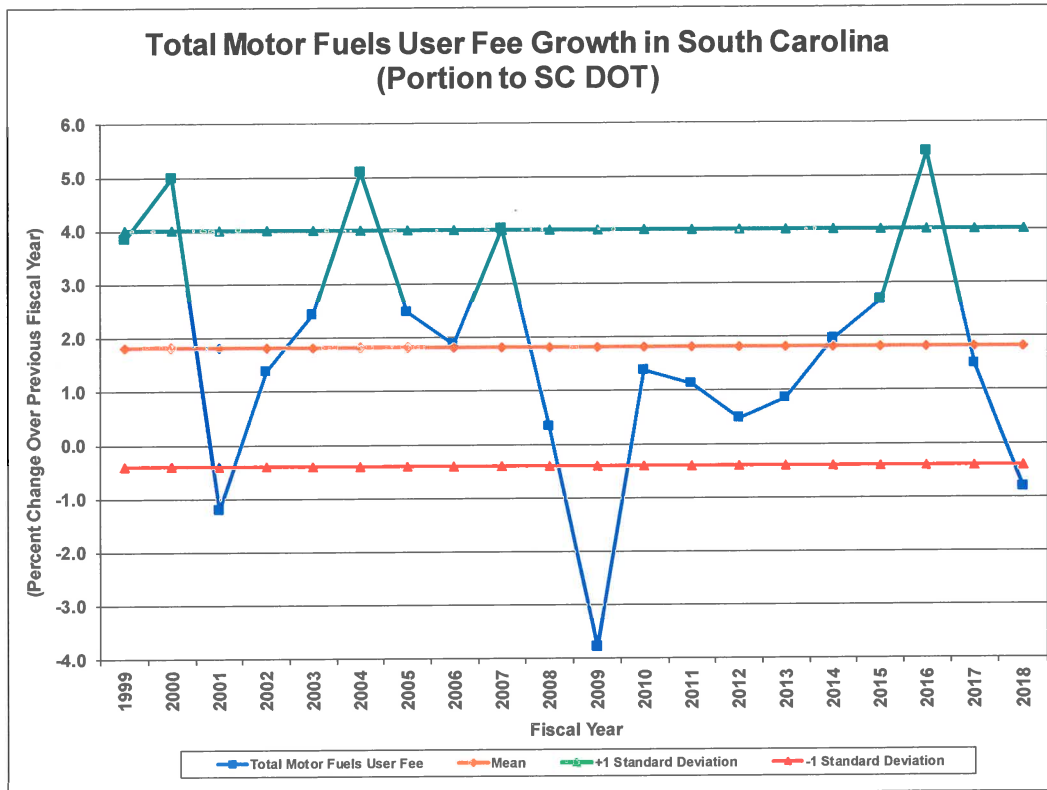
V. The Dunbar-Martin Motor Fuel Demand Model

The demand for motor fuel is dependent on many factors and conditions. Most are quantifiable, but some are not. State economic growth, fluctuating motor fuel prices, increases in the fuel efficiency of vehicles, global crude oil supply and refinery costs, changing motor vehicle preferences of drivers, changing driving habits of drivers, as well as the level of motor fuel tax rates all affect motor fuel consumption.

The data for the empirical models was obtained from state and federal government sources believed to be reliable and timely at the time of model specification. All of the data is subject to strict reporting requirements and is subject to periodic review and revision schedules. The motor fuel demand models are specified as ordinary least squares (OLS) models with each variable converted to natural logarithms before each equation is regressed.

A. The Gasoline Demand Equation

The demand for motor fuel is divided into two separate econometric models – the demand for gasoline and the demand for diesel, or special fuels. The demand for gasoline may be written in the functional form as,

(Equation 1.1) $G_t = f(P_t, Yd_t),$

where:
G_t is the level of gasoline consumption per capita at time t,
P_t is the price of gasoline per gallon at time t,
Yd_t is the level of personal disposable income per capita at time t,
t is any period or observation within the range of observed values in period t.

Many times, the relationship between an explanatory variable (x) and the dependent variable (y) is nonlinear. A scatterplot of the explanatory variables (x) and the dependent variable (y) was examined to observe if there was a nonlinear relationship between them. Then the residuals of the linear model were examined to check for collinearity between the variables. There was no discernable pattern among the residuals. There are several ways to correct for

nonlinearity. The most common technique is to add the quadratic version of a continuous variable to the model.

Gallons of Gasoline Per Capita in South Carolina
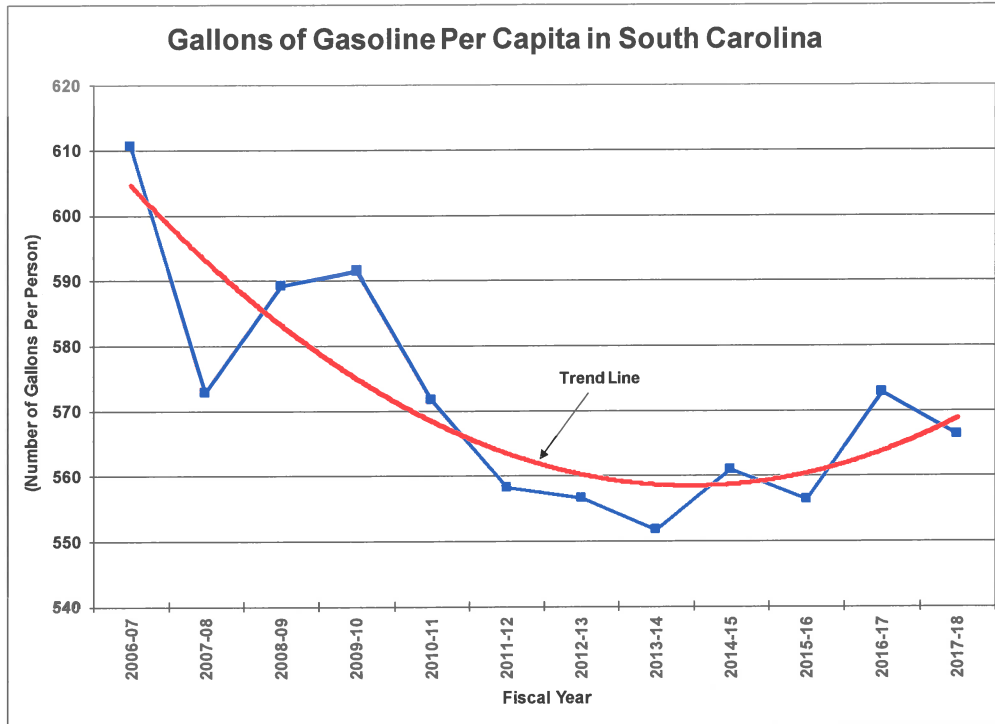
The functional relationship above resembles the trend of a quadratic or polynomial expression. The red trend line portrays a polynomial expression of degree two and shows a trend that is decreasing at a decreasing rate. This functional relationship is incorporated into the gasoline model structure. Generally, the functional relationship may be rewritten and expressed for any period or observations t as:

(Equation 1.2) $\ln G_t = f(\beta_o, \ln P_t, \ln Yd_t, \ln P^2_t, \ln Yd^2_t, u_t)$,

where each independent variable also is expressed as a polynomial term of degree two, an intercept term, β_o, and an error term, u_t, that is randomly distributed around a mean of zero.

The final gasoline demand specification is a log-log model structure where gasoline demand is a function of the price of gasoline, state personal disposable

income, and their quadratic terms. The functional equation above may now be rewritten as:

(Equation 1.3) $\ln G_t = \beta_0 + \beta_1 \ln P_t + \beta_2 \ln Yd_t + \beta_3 (\ln P)^2_t + \beta_4 (\ln Yd)^2_t + \mu_t$

B. The Diesel Fuel Demand Equation

The variables that affect the demand for diesel fuel, or special fuels, behave differently than the variables for gasoline. The same estimation method used in the gasoline model was attempted in the diesel fuel demand model. The model specifications yielded statistically insignificant results for most of the variables selected. The pattern of diesel fuel demand appears to be more linear in recent fiscal years than quadratic in nature as shown in the graph below.
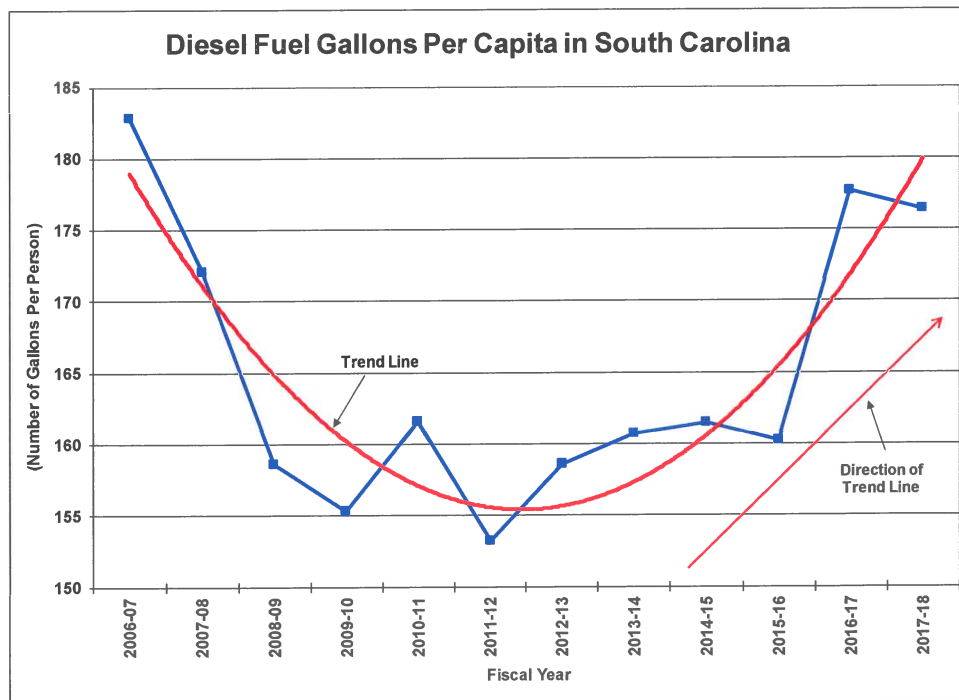
The demand for diesel fuel may be written in the functional form as,

(Equation 2.1) $\ln D_t = f(\ln SCGDP_t, \ln TTU_t)$

where:

D_t is the level of diesel fuel consumption in gallons at time t,

$SCGDP_t$ is the level of gross domestic product in South Carolina at time t,

TTU_t is the level of employment in the trade, transportation, and utilities sector in South Carolina at time t,

t is any period or observation within the range of observed values in period t.

Generally, the functional relationship may be rewritten and expressed for any period or observations t as:

(Equation 2.2) $\quad \ln D_t = f(\beta_0, \ln SCGDP_t, \ln TTU_t, u_t),$

and includes an intercept term, β_0, and an error term, u_t, that is randomly distributed around a mean of zero. The diesel fuel demand model is a log-log model structure where diesel fuel demand is a function of the gross domestic product in South Carolina and the level of employment in the trade, transportation, and utilities industry in South Carolina. The functional equation above may now be rewritten as:

(Equation 2.3) $\quad \ln D_t = \beta_0 + \beta_1 \ln SCGDP_t + \beta_2 \ln TTU_t + \mu_t$

VI. Results

The final gasoline and diesel fuel model's estimation equations are shown below. The gasoline demand model is,

(Equation 1.4) $\quad \ln G_t = \beta_0 + \beta_1 \ln P_t + \beta_2 \ln Yd_t + \beta_3 (\ln P)^2_t + \beta_4 (\ln Yd)^2_t + \mu_t$

The diesel fuel demand model is,

(Equation 2.4) $\quad \ln D_t = \beta_0 + \beta_1 \ln SCGDP_t + \beta_2 \ln TTU_t + \mu_t$

The log-log OLS gasoline and diesel fuel demand econometric models were each regressed separately and the results of each were summed to total motor fuel demand. The results of the forecast model simulation are shown in the tables below. The gasoline demand model had a multiple R statistic of ninety-five percent and the diesel fuel model had a multiple R statistic of ninety-seven

percent. The multiple R statistics is a measure of the "goodness of fit" of the model equation with multiple regressors, or how well the equation explains changes in the model's dependent variable for changes in the independent variable(s). It is the coefficient of multiple correlation. For example, a ninety-five percent multiple R means that the model specification explains ninety-five percent of the variance in the dependent variable by changes in the model's independent variable(s). Only five percent of the change in the dependent variable is explained by something other than what is captured in the model. Also, all of the independent variables are significant at the ninety-five percent confidence interval as measured by the t-statistics shown below. In short, the gasoline demand and diesel fuel demand models are statistically significant specified economic models that can be used to forecast short term fluctuations in the demand for motor fuel.

Summary of Motor Fuel Demand Model Results

Gasoline		Diesel	
Multiple R	0.95	Multiple R	0.97
Variable	**t-stat**	**Variable**	**t-stat**
Intercept	(5.27)	Intercept	2.72
ln P	3.13	SCGDP	6.88
ln Yd	5.92	SCTTU	2.57
ln (P)^2	(3.28)		
ln (Yd)^2	(5.72)		

Note: All variables are statistically significant at the 95 percent confidence level.

The demand for motor fuel was divided into two separate econometric models – the demand for gasoline and the demand for diesel fuel. The individual economic models, gasoline and diesel fuel, were each regressed separately and the results were summed to provide a total motor fuel amount. Although the demand for each type of motor fuel is driven by different independent variables, each model is statistically significant at the ninety-five percent confidence level and each variable in the respective models is statistically significant as well. A summary of the econometric model results is shown in the table below.

Projected Motor Fuel Revenue Collections
Fiscal Years 2018-19 to 2019-20

Fiscal Year	Gasoline Collections		Special Fuel Collections		Total Motor Fuel	
	(Millions)	Growth	(Millions)	Growth	(Millions)	Growth
FY2017-18	$369.743	-1.22%	$113.530	0.55%	$483.273	-0.81%
FY2018-19	$372.129	0.65%	$116.367	2.50%	$488.496	1.08%
FY2019-20	$375.273	0.84%	$119.200	2.43%	$494.473	1.22%

Source: Board of Economic Advisors

The demand for all types of motor fuel in the next two fiscal years will reflect the economic effects of a slowing but stable economy. The growth rates for gasoline and special fuels are positive but will experience growth rates below their long-term average growth rates. The demand for gasoline is forecast to increase by 0.65 percent in FY2018-19 and 0.84 percent in FY2019-20. The demand for special fuels (diesel) is forecast to increase by 2.50 percent in FY2018-19 and 2.43 percent in FY2019-20. The sustained demand for motor fuel is fueled by the growth in population, employment, and income of the labor force.

In 2017, the General Assembly passed an infrastructure bill that will increase the state excise tax on motor fuel by two cents each year for six consecutive years. The first increase of two cents went into effect July 1, 2017 and raised the excise tax to 18.75 cents for FY2017-18. On July 1, 2018, the excise tax was raised by another two cents to 20.75 cents per gallon of motor fuel in FY2018-19. Since the demand for motor fuel is relatively inelastic, the impact of the price changes in the excise tax is very small. The change in the state excise tax rate on motor fuel was incorporated into the econometric model and is reflected in the model results in the table above.

In FY2017-18, the state of South Carolina continued to achieve a level of full employment in the economy. In the fall of 2017, the state weathered a series of three severe tornadoes, Harvey, Irma, and Maria, causing widespread destruction and flooding. These storms damaged several oil refining plants in Texas and Louisiana resulting in a decrease in the supply of gasoline in the Southeast. As a result, motor fuel prices began to increase. Also, OPEC declared a reduction in the rate of oil production and reduced the supply of imported crude oil, further

sending motor fuel prices upward. Based on information from the U.S. Department of Energy, Energy Information Administration, gasoline prices are projected to be at elevated levels but relatively stable throughout the forecast period. As the general rate of growth in the state's economy slows during the forecast period, the rate of growth for motor fuel will fall below its long-range growth rate yet remain positive. As a result, the total demand for motor fuels is forecast to increase by 1.08 percent in FY2018-19 and 1.22 percent in FY2019-20.

VII. Conclusion

The forecasting results of the Dunbar-Martin motor fuel demand econometric model continue to demonstrate encouraging results. The demand for motor fuel was divided into two separate econometric models – the demand for gasoline and the demand for diesel fuel. The individual economic models, gasoline and diesel fuel, were each regressed separately and the results were summed to provide a total motor fuel amount. Although the demand for each type of motor fuel is driven by different key independent variables, each model is statistically significant at the ninety-five percent confidence level and each variable in the respective models is statistically significant as well. Additionally, the results of the gasoline and special fuels econometric models are within one standard deviation of the mean of each variable. These results reinforce the explanatory ability of the motor fuel demand model as a predictive model of future motor fuel demand in South Carolina.

References

AAA of the Carolinas, Charlotte, N.C.

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